NAL PROPOSAL No. 109

Correspondent: Klaus P. Pretzl
Experimental Facilities
National Accelerator Lab
Batavia, Ill. 60510

FTS/Commercial 312 - 231-6600

A PROPOSAL FOR A PRELIMINARY BEAM SURVEY IN THE 3.5 MRAD BEAM

D. Eartly, R. Orr, K. Pretzl, S. Pruss, and A. Wehmann

National Accelerator Laboratory

February 1, 1971

A PROPOSAL FOR A PRELIMINARY BEAM SURVEY IN THE 3.5 MRAD BEAM

D. Eartly, R. Orr, K. Pretzl, S. Pruss, and A. Wehmann

National Accelerator Laboratory

February 1, 1971

ABSTRACT

We propose to measure the yields of positive and negative pions, kaons, and nucleons at 200 GeV/c from several target materials in the 3.5 mrad beam of the Meson Laboratory.

INTRODUCTION

We propose to perform a preliminary particle survey in the 3.5 mrad beam of the Meson Laboratory. This will be a natural extension of our responsibility for bringing this beam into operation and would require very little extra equipment. No changes of the beam as designed for subsequent experiments will be necessary.

We believe that the measurement of particle production cross sections is of great importance for this Laboratory. First, the knowledge of secondary particle fluxes is necessary for planning experiments and future experimental areas at NAL. Second, extensive measurements on secondary particle production cross sections done in other laboratories at lower energies should be continued up to NAL energies. The results would enhance our knowledge of the reaction mechanism involved and be useful for testing existing model predictions at high energies.

Our plan is to measure the production of positive and negative pions, kaons, and nucleons at 200 GeV/c from several target materials (Be, Cu and W). The measurements will be made at different production angles between 0 and 10 mrad and for secondary particle momenta from 30 GeV/c up to the maximum momentum that is kinematically allowed. For 3 targets, 9 secondary momenta, 2 polarities and 3 production angles, 200 hours of running time after installation and optical tuning of the 3.5 mrad beam will be necessary. Most of this time will be spent in changing conditions. The expected point to point relative error is 5% for secondary momenta below 100 GeV/c, 10% between 100 and 150 GeV/c and greater than 20% for higher secondary momenta.

EXPERIMENTAL METHOD

The first two stages of the 3.5 mrad beam will be used for momentum analyzing and detecting secondary particles, which emerge from a target in the target box. A variable horizontal and vertical collimator in front of the first quadrupole in the 3.5 mrad beam will limit the horizontal and vertical angular acceptance of the system, thus allowing us to control the particle flux to a convenient level. The maximum solid angle acceptance has been determined to be 2.0μsterad. Figure 1 shows a general layout of the 3.5 mrad beam and the target box. An envelope trace of the beam optics is shown in Fig. 2. The 3.5 mrad beam is briefly described in the Appendix.

The total charged particle flux transmitted through the beam will be measured by a series of scintillation counters, $S_1 \ldots S_6$, whose horizontal and vertical dimensions determine the phase space acceptance of the beam. A wire proportional chamber at the dispersed focus F_1, in coincidence with the counters $S_1 \ldots S_6$ allows us to measure the momentum acceptance of the beam. This chamber will also be used as a beam profile monitor and is expected to be part of the standard beam instrumentation of the 3.5 mrad beam. We can also independently implement this chamber if necessary. The maximum momentum-resolution of the beam is estimated to be $\Delta p/p = 0.2\%$ FWHM taking a 1 mm diameter object size into account. The effective momentum resolution will be determined by measuring the momentum peak of elastic scattering.

The particles will be identified by a system of 3 threshold

Cerenkov counters C_1, C_2, and C_3 with a diameter of 16 inches and a length of 100 feet, 130 feet, and 100 feet respectively. For measurements above 75 GeV/c the counters will be filled with He gas and below 75 GeV/c with N_2 gas. The Cerenkov light in each counter will be collected by a spherical mirror and focused onto one photomultiplier. By summing the signals of all 3 Cerenkov counters we expect an efficiency for counting π's and no K's at 180 GeV/c of greater than 99.9%. With three Cerenkov counters we will be able to determine the particle ratios in several independent ways and thus cross check the results.

A 2 m long Fe absorber at the very end of the beam line and a scintillation counter telescope S_7, S_8 in coincidence with $S_1 \ldots S_6$ determines the μ-meson component in the beam.

The production angle of the secondary particles accepted by the 3.5 mrad beam can be varied between 0 mrad and 10 mrad by two horizontal steering magnets $EPBM_1$ and $EPBM_2$, which will be mounted on railroad cars in the target box. A fast response position monitor just in front of the production target will be used to established that the proton beam is hitting the target. (The monitor could be used to servo the steering magnets $EPBM_1$ and $EPBM_2$, or to gate our electronics.) In addition, we would utilize high spatial resolution low-pass band detectors to determine the mean angle of incidence during each spill.

The particle flux in the external proton beam will be monitored by a secondary emission monitor (SEM) and/or by an ion-chamber. A scintillation counter telescope looking at large angle (preferably 90°) at the production target will serve two purposes: 1) to monitor the relative proton beam intensities, and 2) to demonstrate the proton beam is correctly hitting the target. External proton beam intensities of 10^{10}-10^{11} particles/sec would be most satisfactory. Both monitors will be calibrated by a fast spill toroid and/or a foil activation method.

Small cylindrical targets will be mounted on a remote controlled manipulator, which is already designed.

REQUIREMENTS

The instrumentation used in this study is standard equipment for the 3.5 mrad and for the target box in the Meson Laboratory. A very minimum amount of electronic logic will be required, i.e. a few coincidence circuits, discriminators, and scalers. The estimated value of electronics is $20K. However, the required electronics might be available through PREP. Measurements above 140 GeV/c would best be done with 3 Cerenkov counters. Two of the required Cerenkov counters will be used subsequently for the total cross section experiment and the differential cross section experiment, which are both scheduled in the 3.5 mrad beam. We hope a third Cerenkov counter would be made available to us. The estimated value is $5K.

APPENDIX

The beam can be characterized as a 3-stage beam with two intermediate foci. The quadrupole doublet Q_1,Q_2, made out of three 10-ft. long half quadrupoles, focuses the particle horizontally point-to-point and vertically point-to-parallel at the momentum slit F_1. The horizontal dispersion of 3 cm per 1% is provided by a string of four bending magnets M_1, M_2, M_3, and M_4 with a total bend angle of 37.2 mrad. The horizontal magnification at that focus is 1.9. The off-momentum rays will be recombined by a quadrupole doublet Q_3, Q_4, which acts as a field lens, and by a string of three bending magnets M_5, M_6, M_7 with a total bend angle of 36.0 mrad. The doublet Q_5, Q_6 then produces an achromatic focus in both planes at F_2 approximately 860 ft. downstream of the production target. Finally, the beam is focused point-to-parallel in both planes by the doublet Q_7,Q_8.

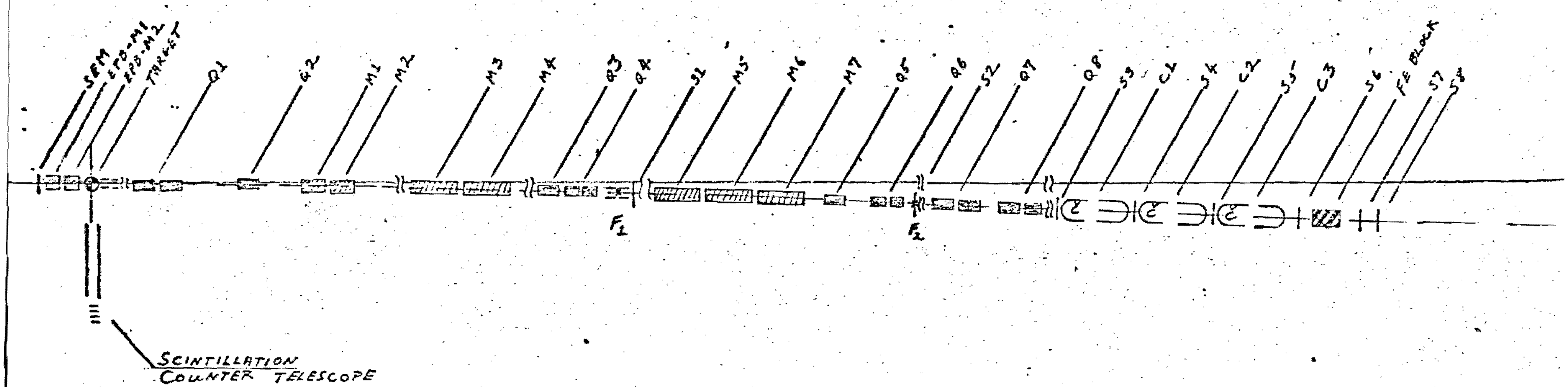
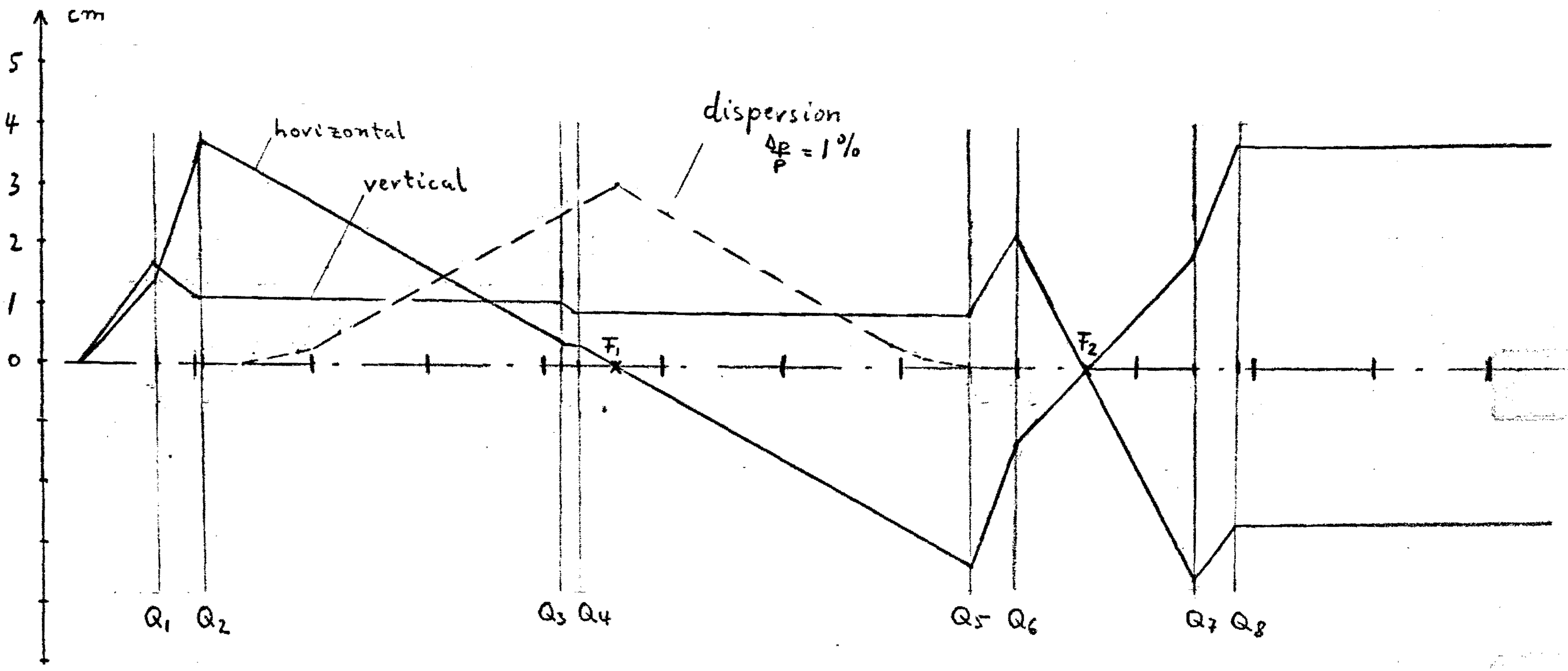

SEM
EPB-M1
EPB-M2
TARGET
Q1
Q2
M1
M2
M3
M4
Q3
Q4
S1
M5
M6
M7
Q5
Q6
S2
Q7
Q8
S3
C1
S4
C2
S5
C3
S6
FE BLOCK
S7
S8
F1
F2
SCINTILLATION
COUNTER TELESCOPE

FIGURE 1



horizontal and vertical
envelope trace of 3.5 mrad beam.

Figure 2